

ONEOKLAHOMA

A Strategic Plan for Science
and Technology - 2016



Governor's Science & Technology Council

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Executive Summary

In 2006, the National Academies of Science published a report “Rising Above the Gathering Storm” in which they made several recommendations that in their view were essential for the US to maintain its quality of life and grow its economic prosperity. The top recommendations had to do with STEM education. The second priority recommendations had to do with research and development.

Here in Oklahoma, in 2012, the Governor’s Science and Technology Council published its Strategic Plan for Science and Technology in Oklahoma, called “OneOklahoma”. This plan also concluded that the important economic development priorities for the state were in STEM education and research and development. The current 2016 plan is an update and revision of the 2012 plan, in response to the changing science and technology environment within our state.

The 2016 plan emphasizes that investment in and sustainment of Science & Technology (S&T) in Oklahoma is vital for the economic growth of our state. All of the main industries in the Oklahoma “ecosystem” are S&T industries at their core (energy, aerospace and defense, information systems, etc.). These wealth-generating industries are built upon an educated and well-trained STEM workforce. A good STEM foundation in education leads to greater employment opportunities and careers, both in existing, established companies and in young, small entrepreneurial businesses in the S&T sector. S&T industry leads directly to improvement in the wellbeing and way of life for all citizens of Oklahoma.

To realize these goals, however, Oklahoma has to invest in both STEM education (from K-12 to higher education) and in continued research and development at the leading edge of science and technology. The state has a STEM workforce skills gap that must be addressed. This includes changing the conversation from educators talking to other educators about education to industry members talking to educators about careers and alignment with the needs of business. Only in doing so will education be able to address both the relevance of STEM subjects along with the necessary rigor to achieve success.

Oklahoma research and development (R&D) establishments, both public and private, must work together. Critical masses must be achieved in strategic research areas

by combining and sharing resources. Competitiveness at the national level will best be achieved if such a strategy is adopted. State-wide entities that oversee R&D within the state must identify competitive research directions and support them with priorities and funding, whenever possible. The recent annual declines in state support for R&D and entrepreneurship must be reversed as soon as the state budget improves and allows such investment.

In support of the above, the Governor's Science & Technology Council make the following recommendations in the areas of STEM Education, Research and Development, and Innovation.

RECOMMENDATION 1:

Coordinate I

All stakeholders – in the Education, Workforce Development and Economic Development Communities - should collaborate, coordinate and align priorities, goals and initiatives in order to create a common vision and set of goals for the improvement of STEM Education in the state. Focused and actionable plans should be developed to increase student access to and success in rigorous and relevant STEM-based education.

RECOMMENDATION 2:

Recruit & Reward

Implement strategies to recruit, develop, reward and retain excellence in STEM teachers in all three Oklahoma education systems (Higher Education, Career Technology Centers, and K-12 districts).

RECOMMENDATION 3:

Form STEM Communities

Enhance and grow STEM recognition opportunities for communities, schools and students.

RECOMMENDATION 4:

Show Relevance

Foster innovative ways to engage students in understanding STEM career opportunities, both early and often.

RECOMMENDATION 5:

Diversify

Take definitive steps to meaningfully broaden the participation of women and traditionally underrepresented minorities in all STEM activities.

RECOMMENDATION 6:

Prioritize

Prioritize rebuilding investment into science, technology and innovation when funds are available.

RECOMMENDATION 7:

Report

Ensure that Oklahoma's citizens receive the maximum benefit from state investments in science and technology.

RECOMMENDATION 8:

Discuss

The Governor should convene a focused summit on the "Future of the Oklahoma's Science & Technology Enterprise", organized by OCAST/OSTRAD, and including all primary stakeholders and decision-makers, to discuss the role of S&T innovation and investment to the state's economy and receive recommendations from stakeholders regarding future investment directions.

RECOMMENDATION 9:

Coordinate II

Coordinate with the State EPSCoR Committee as a mechanism for helping execute the State S&T Plan.

RECOMMENDATION 10:

Collaborate

By utilizing the collective capabilities of Oklahoma's academic, corporate, Tribal, K-12, and non-profit research institutions, establish a single virtual research organization in Oklahoma – informally termed here "OneOklahoma" – that can be brought to bear on certain national and international challenges and opportunities.

RECOMMENDATION 11:

Aim High

Undertake a concerted effort to establish a major federal research laboratory in Oklahoma and/or provide space for national observing and research support facilities.

RECOMMENDATION 12:

Advocate

Explore the creation of an industry-led advocacy group to bring important corporate and other interests to the table when planning, defining and executing the state's economic development/research and development agenda.

RECOMMENDATION 13:

Promote

Develop and execute a coordinated strategy for promoting/marketing Oklahoma science and technology nationally

Each of the above recommendations is expanded and discussed in detail in the body of the report.

ONEOklahoma: A Strategic Plan for Science & Technology 2016

“Start with the End in Mind”: A Vision for Oklahoma

The recommendations in this Strategic Plan will help make Oklahoma a place where:

- investments are made by the state to develop the intellectual capital of our people in order to realize the opportunities and benefits that come with the application of science, technology, engineering and mathematics (STEM);
- businesses and industries create wealth due to the availability of a well-educated, trained and motivated workforce capable of applying science, technology, engineering and mathematics skills;
- out-of-state businesses and industries can consider as a vibrant place to relocate;
- legislators work in support of and advocate for the necessary programs to grow science, technology, innovation and entrepreneurship, and create a qualified STEM workforce to support this growth;
- industry and business leaders stress the importance of and participate in mentoring, internships and classroom activities;
- career pathways are part of a culture started early in the education process and last beyond formal education, where the pursuit of advanced academic degrees and higher levels of technical certification is encouraged and realized;
- STEM teachers are exceptionally qualified, rewarded and recognized for their outstanding contributions to Oklahoma;
- all students have access to advanced education and training due to a robust, common, technical and higher-education system and a network of distance learning capabilities;
- communities put a high priority on STEM education and training and create partnerships with businesses and industries to the benefit of all;
- STEM education does not end with the school bell but continues with state-wide, after-school networks and programs; and
- a high quality of life and opportunity are realized by Oklahoma citizens due to science and technology business growth, with high-paying STEM jobs and careers that make a difference.

ONEOklahoma: A Strategic Plan for Science & Technology 2016

1. INTRODUCTION

In a pivotal 2006 report, “Rising Above the Gathering Storm”, the National Academy of Science made a series of recommendations regarding the growth of economic prosperity for the citizens of the United States. It is of note that the top two priorities in that report, which dealt with the US’s economic competitiveness, were to do with, first, STEM education and, second, research. As stated by Norm Augustine, the chair of the Gathering Storm committee, “Numerous studies have indicated that 87% of the GDP growth in the US comes from advances in just two disciplines: science and technology. However, only 5% of the nation’s workforce are scientists or engineers!”

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”

- Norm Augustine, National Academy of Science

Here too in Oklahoma, the application, sustainment and growth of science and technology (S&T) is a wealth generator for Oklahoma. All of the main industries in the Oklahoma “ecosystem” are S&T industries at their

core (energy, aerospace and defense, information systems, etc.). National statistics indicate that two-thirds of all economic growth in states comes from investment into S&T innovation and industry. Growth of S&T starts with education, specifically STEM education. A good STEM foundation in education leads to greater employment opportunities and careers. Data indicate that the growth rate of STEM jobs will outpace non-STEM jobs. According to the Oklahoma Employment Security Commission STEM-related jobs pay an average wage of \$72,726 compared to an average wage of \$39,940 for all occupations. Education leads to a well-trained, qualified S&T workforce. This in turn leads to entrepreneurial activity, economic growth, and economic wellbeing for all citizens of Oklahoma. This is the basis of the Science & Technology “Wealth Generation Cycle” **(See Figure 1)**.

Although Oklahoma is becoming a thriving environment in which to get STEM-based jobs (Oklahoma City is ranked the 7th best metro area in the country for STEM professionals (<http://wallethub.com/>); Tulsa is ranked 44th) there is still much to do for all our citizens. Even with all the progress in recent years, Oklahoma continues to have an economy based primarily on exploitation of natural resources, tied to cyclical variation in commodity pricing.

This 2016 “OneOklahoma” Strategic Plan builds upon the 2012 Strategic Plan created by the Governor’s S&T Council. It follows the same theme as the earlier plan in that it builds on STEM education as a base. Compared with the 2012 plan, however, the 2016 Plan places more focus on collaborative research leading to innovation and entrepreneurship.

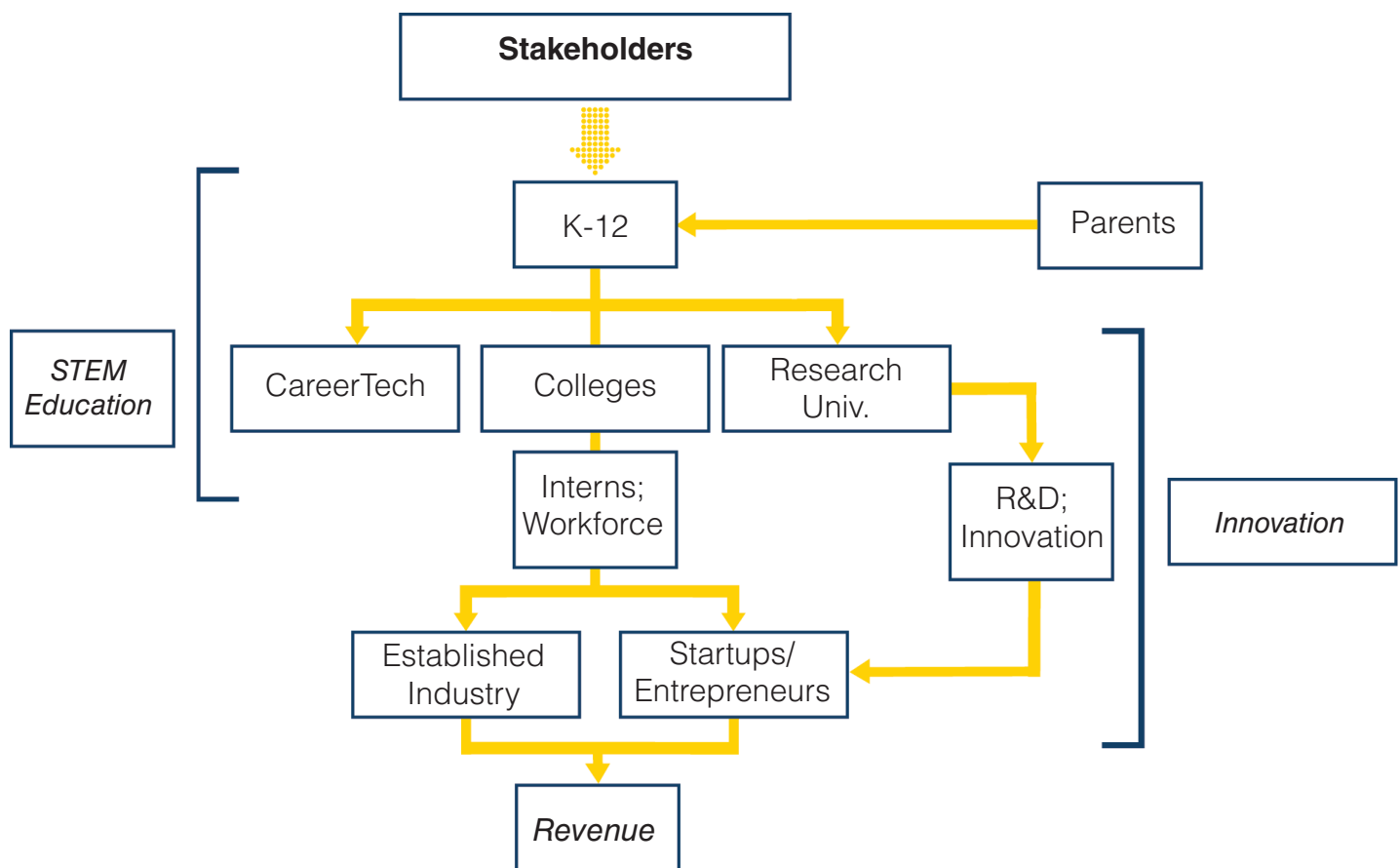


Figure 1: The Wealth Generation Cycle

2. THE IMPORTANCE OF STEM EDUCATION IN OKLAHOMA

2.1 The Workforce Skills Gap

Multiple commentaries, analyses and studies conclude that the nation, Oklahoma included, is not producing enough STEM-qualified workers to meet the needs of our state and the nation. There are simply too few young people taking STEM classes, in K-12, Career Tech and College, to feed the workforce needs of Oklahoma. Some numbers illustrate this fact:

- In 2014 the Oklahoma Department of Commerce estimated that Oklahoma has 158,939 STEM-related occupations, representing 9.5% of the state's overall occupational mix.
- By 2024, Oklahoma is forecast to have 188,619 STEM-related occupations, a growth of 19% from 2014. By comparison, the total job growth in Oklahoma is forecast to be 13% over the same period.
- Between 2014 and 2024, the average annual STEM-related openings in Oklahoma are expected to be 6,701 per year.
- Over the same period Oklahoma is expected to replace 40% of the existing (2014) STEM workforce.
- Of the STEM occupations listed, 70% require a Bachelor's degree, or higher.
- Approximately 96% require some level of post-secondary education.
- Data from the Oklahoma State Regents for Higher Education (OSRHE) for 2012-2013 indicated that there were 6,058 STEM post-secondary degrees (associates, bachelors, masters, doctorate) from Oklahoma institutions of higher education.

Using Oklahoma Department of Commerce figures of 96% of STEM jobs requiring post-secondary education, there is a need for approximately 6,400 STEM-qualified, post-secondary graduates per year entering the Oklahoma workforce. On the face of it, therefore, it would seem that Oklahoma is producing almost enough STEM graduates (6,058) to match workforce needs. However, the post-secondary graduation numbers do not account for the loss of graduates from the STEM pipeline, nor do they account for the number of international students and out-of-state students who leave Oklahoma after graduating. According to the Georgetown Center on Education and the Workforce, the national average loss of STEM-qualified graduates from the pipeline leading to STEM-required occupations is 43%. Further, the Oklahoma State Regents for Higher Education (OSRHE)

estimate that 30% of graduates from Oklahoma institutions of higher education leave the state upon graduation. With these losses in mind, the net figure is that Oklahoma is producing only approximately 2,400 post-secondary STEM graduates per year to fill the roughly 6,400 STEM related occupations. Although the numbers do not account for STEM-qualified immigrants into the state, the data demonstrate that Oklahoma is not producing enough STEM graduates to support Oklahoma’s industries and help the close the large workforce skills gap.

One consequence is that the STEM pipeline is extremely “leaky”. Data from the Georgetown Center for Education and Workforce reveal that the national STEM pipeline loses the vast majority of its STEM-qualified individuals between graduating from High School and entering the workforce (**See Figure 2**).

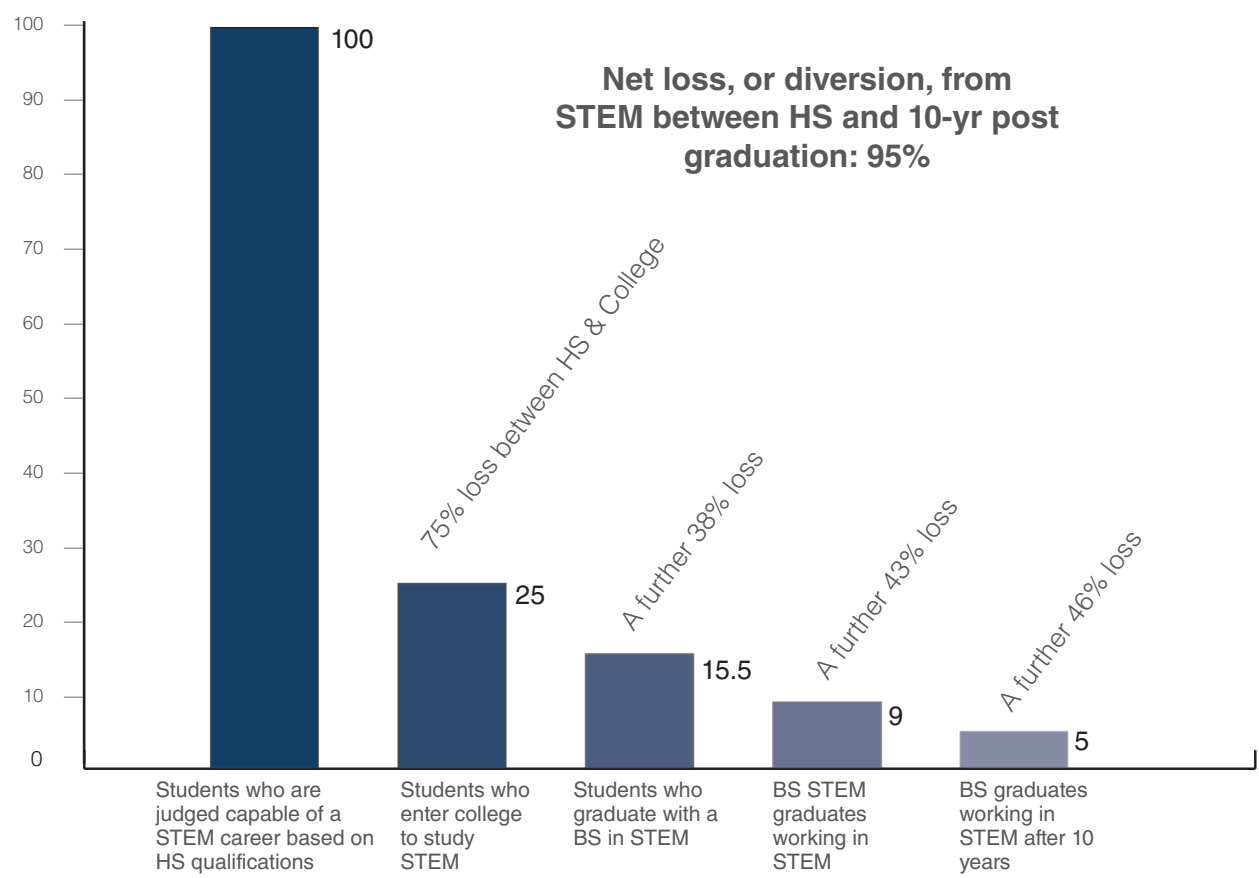


Figure 2: Loss from the STEM Workforce Pipeline; National Data

2.2 The Causes

What is the cause of such a large workforce skills gap? The answer is multifold but can be summarized as issues of “rigor” and “relevance.”

Rigor:

- In addition to a workforce skills gap in industry there is also one in education. There are insufficient numbers of STEM-qualified teachers in Oklahoma. Many of our Oklahoma teachers can be described as “generalists” and not “specialists.” They are aware of the educational goals of the subject but not of the application in career pursuits...i.e. the relevance. Without that understanding, motivation is difficult to create, and rigor is difficult to apply.
- As a result, STEM classes are either not being taught, or being taught by teachers who lack the requisite skills.
- Furthermore, there are insufficient resources to enable science labs to be taught in many schools, or for distance learning opportunities for rural schools.
- Additionally, too many students avoid the necessary courses at the right time — e.g. algebra in 8th or 9th grade, or calculus, or physics, or chemistry in higher grades.
- This results in over 40% of high-school graduates requiring some remediation, primarily in Math, at the post-secondary level.

The net result is that not only does Oklahoma rank poorly in national STEM performance metrics (see Table 1 on page 15 as an example), but also — and perhaps as importantly — both

teachers and students do not recognize the relevance of the necessary classes for getting STEM-related jobs.

Relevance:

- Students, teachers and parents are often unaware of the myriad of STEM-job opportunities that are available.
- The STEM curriculum is often not aligned with current and future STEM employment opportunities.
- Too many students leave high school with insufficient backgrounds in science and math to succeed in post-secondary education and, ultimately, the workforce.

2.3 A Role for Industry

One critical need to help address this issue is industry support in the classroom. Teachers need to visit industry in order to become familiar with opportunities and the needed skills. Likewise, industry needs to visit the classrooms to educate students about the same. Honest discussions about needed resources and relevancy also need to occur.

Industry’s workforce of the future is sitting in today’s classrooms. Industry needs to work with Oklahoma’s education establishments to enable relevant instruction at the right grade in

Education should not be thought of as a means to a diploma, but as a means to a satisfying career. We simply must change the conversation from educators talking to other educators about education to industry members talking to educators about careers. *Oklahoma’s economy depends on it.*

order to produce the qualified graduates that industry needs. Education should not be thought of as a means to a diploma, but as a means to a satisfying career. We simply must change the conversation from educators talking to other educators about education to industry members talking to educators about careers.

Oklahoma's economy depends on it.

3. THE IMPORTANCE OF SCIENCE & TECHNOLOGY IN OKLAHOMA

3.1 Research and Development

Computers, smartphones, the internet, robotics, oil and gas, renewable energy, water resources, agriculture, defense and security, transportation, aviation and aerospace, pharmaceuticals, medical imaging, it is difficult to name an area of our modern life that does not involve science and technology. Each has led to growth and diversification in our economy which makes us less impacted by downturns in any one sector while at the same time improving our quality of life. Likewise, it is difficult to identify any one of these innovations that did not require investment years, even decades, earlier in order to reach a pay-off in terms of commercial benefit for industry and quality-of-life improvements in our society.

Historically the US was the scientific and technological global leader in all of these areas. Not so now for many of them. Whether through a lack of vision, or foresight, or leadership, or understanding, or money, or all of the above, the US has allowed its global research and development (R&D) position to shrink and be shifted to Europe and Asia. US investment in R&D, as a percentage of GNP, is now lower than at any point in the past 50 years.

In addition to the US's decline globally in science and technology, Oklahoma continues to lag other US states. Table 1 illustrates the

science & technology indicators for Oklahoma compared with the other states. Generally, the state falls within the 3rd or 4th percentile in most categories. We can and must improve. Ross DeVol, Chief Research Officer at the Milken Institute, notes that two-thirds of the economic growth of a state can be directly explained by investment in innovation and high-tech industry. Examples in Oklahoma include breakthroughs in energy, aerospace, agriculture and other areas. These came about from investments in R&D, from private and public sources, made decades ago. The investments have positioned us to take advantage of new technological developments in these and emerging areas.

Innovative capacity derived through universities, R&D investments, scientists and engineers, highly skilled workers, and entrepreneurial capabilities is increasingly the driver of competitive success among states (Information Technology and Innovation Foundation, The 2014 State New Economy Index). The State New Economy Index (<http://www.itif.org/publications/2014/06/11/2014-state-new-economy-index>) is a system based on scoring among 25 indicators in five key areas: Knowledge Jobs, Globalization, Economic Dynamism, The Digital Economy, and Innovation Capacity. In 2014, Oklahoma ranked 48th among the states.

Workforce development is critical to Oklahoma's future. We must not, however, lose sight of the importance of the specialized nature of training for technicians, scientists and engineers for the leading roles they will play in our 21st century economy. Innovators and entrepreneurs, many of whom are engineers and scientists, are critical for transforming the results of research into real capabilities and technologies that benefit society. Fundamentally, R&D is the foundation of their activity and achievement, and is what enables the creation of the jobs they provide for our citizens. Common education prepares some for the workforce, some for

additional technical education, and others for additional higher education opportunities. Ours is a segmented system of higher education consisting of 2- and 4-year undergraduate institutions, 4-year and master's degree granting institutions, and doctoral and professional degree granting institutions. Each has a crucial role in preparing our young people to take their place in the 21st century economy. But the training of scientists, engineers and other professionals requires robust programs of R&D activity at our doctoral and professional degree granting institutions to provide the advanced level of teaching and learning activity necessary to solve complex problems, create new knowledge and produce innovative technologies.

Nevertheless, recent years have seen a decline in Oklahoma's S&T investment. The state's

“Two-thirds of the economic growth of a state can be directly explained by investment in innovation and high-tech industry.”
- Ross DeVol, Milkin Institute

agency for technology development, transfer and commercialization, the Oklahoma Center for the Advancement of Science and Technology (OCAST), has seen a decline in its budget from a high of \$22.9 million in FY2008 to its current low of \$15.9 million in FY2016 (Figure 3). Over the last 5 years, state appropriations for higher education have fallen by more than 10 percent. Revenues for higher education, in general, grew at a slower pace than the U.S. average, even

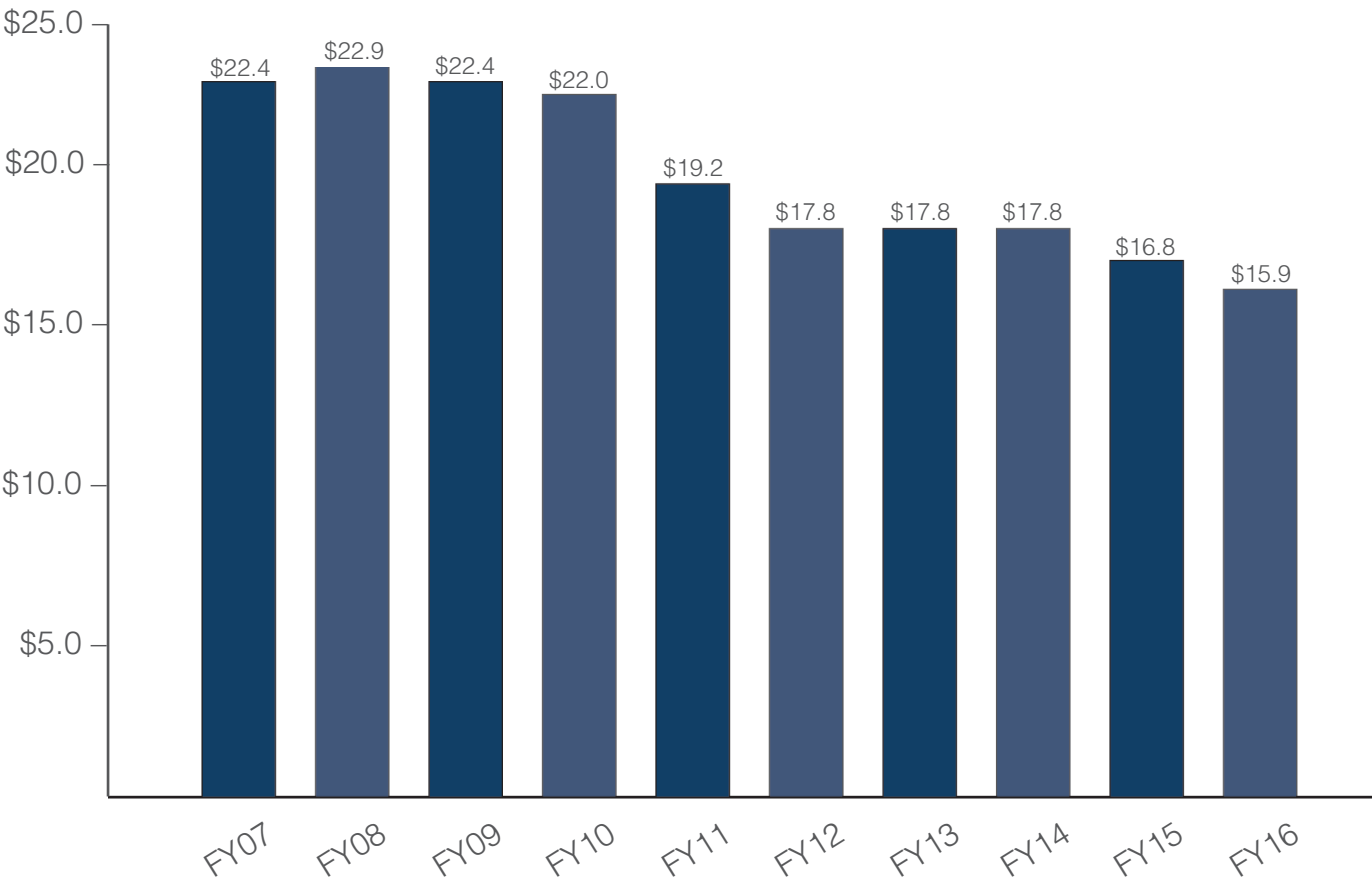


Figure 3: OCAST Appropriations History, FY17-16

Indicator		Average State Performance		# Students at Proficiency	
		Percentile	Av. Score	Percentile	# Students
STEM Education Workforce	4th Grade Math	3rd	47%	4th	33%
	4th Grade Science	3rd	49%	3rd	28%
	8th Grade Math	3rd	56%	4th	27%
	8th Grade Science	3rd	49%	3rd	26%
	Percentile		Av. Score	Top Ranking States	
	# students taking AP in HS	3rd	21.5%	Florida, 51%	
	AP score of 3 or higher	4th	10.6%	Maryland, 28.1%	
	AP Calculus score of 3 or higher	4th	3.6%	Indiana, Maryland 10%	
	# HS Graduates	3rd	87.8%	Hawaii, 94.9%	
	STEM associate degrees (per 1,000 students)	1st	5.7	Arizona, 20	
	STEM BS degrees (as a % of all degrees)	4th	24.7%	Washington, D.C. 40.7%	
	STEM advanced degrees (as a % of all degrees)	2nd	26.0%	Washington, D.C. 48.6%	
	STEM PhD degrees (as a % of all degrees)	3rd	3.7%	Delaware, 6.8%	
	Individuals in STEM workforce (as a % of all in workforce)	4th	3.3%	Washington, D.C. 9.73%	
R&D	Federal R&D (as a % of GDP)	4th	0.7%	New Mexico, 8.1%	
	State R&D (per \$1M of GDP)	2nd	\$130	West Virginia, \$535	
	Business R&D (as a % of business output)	4th	0.47%	Washington, 4.76%	
	Academic R&D (per \$1M R&D funds)	4th	\$2.57	Maryland, \$10.44	
	Academic papers (per 1,000 STEM PhDs)	4th	309	Deleware, 636	
	Academic papers (per \$1M R&D funds)	2nd	2.74	Wyoming, 4.08	
Innovation	Patents (per 1,000 STEM workforce)	2nd	12.1	California, 24.7	
	High-tech business (as a % of all businesses)	2nd	8.47%	Washington, D.C. 16.3%	
	SBIR \$ (per \$1M GDP)	4th	\$13	Massachusetts, \$225.00	
	Venture capital \$ (per \$1M GDP)	4th	\$0.21	Massachusetts, \$7.74	
	Venture capital (as a % of all businesses)	4th	0.03%	California, 1.5%	

after adjustment for inflation and cost of living (SHEF — State Higher Education Finance FY14). With enrollment in higher education at an all-time high in Oklahoma, institutions of higher education continue to be under strain. It is understood that legislators face difficult decisions in tight budget years, when revenues are in decline and it becomes likely that cuts, not investments, are the more likely. However, we should still not lose sight of the fact that R&D investment leads to economic growth, future prosperity, health, and stability.

The decline in state investment into R&D is also reflected in the rankings for the state’s S&T efforts. **Table 2** (below) lists the rankings for the state where it can be seen that the state ranks high in terms of being pro-business, but the outlook for long-term growth in the innovation sector is reflected in the low rankings for patents, R&D expenditures and venture capital investment.

STEM education plays an essential role in this dynamic. A thriving technological and innovation-based economic sector requires a scientifically and technologically educated workforce at all levels, from technical staff to scientists and engineers.

OKLAHOMA’S PLACE IN THE RANKINGS			
1st	Cost of living	29th	Per capita personal income
3rd	Job growth	29th	Real gross domestic state product
4th	Cost of doing business	29th	State and local taxes
6th	Lowest cost of labor	30th	Manufacturing employment
7th	Corporate tax rate	33rd	Granted Patents
10th	Top states for doing business	36th	R&D expenditures
26th	Annual earnings and income	38th	Exports
28th	Population (3,850,568)	40th	Venture Capital

Table 2: Economic Indicator Rankings for Oklahoma

The following sections describe a list of recommendations made by Oklahoma’s Science & Technology Council. These follow a set of recommendations made four years earlier (2012) under the title “OneOklahoma: A Strategic Plan for Science and Technology in Oklahoma, 2012”. (We include in the Appendix a description of the recommendations from the 2012 Strategic Plan and briefly describe the progress made since that time.)

ONEOklahoma: A Strategic Plan for Science & Technology 2016

2016 Recommendations

4.1 STEM Recommendations

RECOMMENDATION 1: COORDINATE I

All stakeholders – in the education, workforce development and economic development communities – should collaborate, coordinate and align priorities, goals and initiatives in order to create a common vision and set of goals for the improvement of STEM education in the state. Focused and actionable plans should be developed to increase student access to and success in rigorous and relevant STEM-based education.

By supporting the “Oklahoma Works” initiative and the recommendation of the 2012 S&T Council Strategic Plan to grow a community focus regarding STEM workforce issues (i.e. STEM Communities), Oklahoma stakeholders can see the impact of STEM education on the Oklahoma regional economies. The efforts exemplified in “Oklahoma Works” to improve STEM education by collaborating with Oklahoma institutions of higher education, career technology centers, K-12 districts and industry will ultimately strengthen the state’s workforce pipeline. Measurable benchmarks for STEM education will include, among possible others, increased student achievement in STEM courses, increased college readiness, increased college-enrollment rates, increased STEM certifications

awarded and increased STEM degree completion.

STEM education should remain a priority for schools and higher-education institutions. In addition to aligning the priorities of the three groups noted above (Education, Workforce Development and Economic Development) we should ensure that the various entities within these groups likewise share a common set of priorities and goals.

The S&T Council also recommends:

- Advocating, endorsing and supporting STEM education programs such as AP math and science and Project Lead The Way (PLTW) STEM programs in engineering, biomedical sciences and computer science throughout the state. These programs provide access for all students, including underrepresented students. A goal of making PLTW available throughout all Oklahoma should be adopted.
- Creation of a statewide STEM education and Industry Advisory Group to foster the development of public/private partnerships to support and grow STEM education.

Recommendation 2: RECRUIT & REWARD

Implement strategies to recruit, develop, reward and retain excellence in STEM teachers in all three Oklahoma education systems (Higher Education, Career Technology Centers, and K-12 districts).

The shortage of teachers in the Oklahoma K-12 system is now critical, 50% of the shortage being in qualified STEM teachers. Therefore, the S&T Council recommend:

- Establishing partnerships among comprehensive school districts, regional technology centers and universities, science agencies, businesses and other community partners to attract new, qualified STEM teachers into the Oklahoma K-12 system. One recent example is the OSUTeach program at Oklahoma State University, but more needs to be done. The state should consider developing an industry sponsorship program for STEM teachers.
- Targeting resources to support these initiatives and to cultivate a talented and well-trained STEM teacher pool that can play a critical role in inspiring and preparing Oklahoma's next generation of STEM employees.

The 2012 S&T recommendation to establish STEM Communities and a "STEM State-of-Mind" is achieving recognition of the importance of STEM education to regional economies. The "Oklahoma Works" initiative is a critical program to build further community engagement. Furthermore, students need to know that they have met required milestones in K-12 if they aspire to pursue STEM careers. To support this the S&T Council recommends:

- Establishing and supporting a recognized and widely adopted "STEM-ready" designation to identify students that reach designated benchmarks in multiple education milestones. This could include, but not be limited to, AP or advanced math/science courses, ACT or SAT scores, PLTW end-of-instruction exams in Engineering, Bioscience or Computer Science, or perhaps others.
- Establishing and supporting school-level recognition for schools/technology centers/colleges & universities that increase student achievement in STEM fields.
- Continuing to support and grow the STEM State-of-Mind/STEM Communities recognition process for Oklahoma communities.
- Developing part-time experiential apprenticeship programs for high school students.

RECOMMENDATION 3: FORM STEM COMMUNITIES

Enhance and grow STEM recognition opportunities for communities, schools and students.

RECOMMENDATION 4: SHOW RELEVANCE

Foster innovative ways to engage students in understanding STEM career opportunities, early and often.

Oklahoma students need to be aware of and up-to-date with the changing opportunities for STEM careers, and to be aware of the necessary courses and subjects to achieve those goals. The S&T Council therefore recommend:

- Integration of STEM education and its components with other areas of study to establish more meaningful and seamless learning opportunities for students K-12.
- Publicizing, promoting and supporting extra-curricular STEM programs, which highly engage, motivate and inspire all students (e.g. FIRST Robotics, Tulsa's Flight Night, etc.)

RECOMMENDATION 5: DIVERSIFY

Take definitive steps to meaningfully broaden the participation of women and traditionally underrepresented minorities in all STEM activities.

Increasing participation in science & technology from underrepresented groups is a nationwide-issue. For Oklahoma, the S&T Council recommends:

- Creation of a statewide taskforce to gather information and assess existing programs and resources to better understand the nature of our challenges and possible interventions throughout the academic pipeline. Representatives from all institutions, including tribal colleges and community colleges should participate on the taskforce as both a means to contribute knowledge and leverage existing programs and resources at our universities to find collaborative opportunities.

- Provide a means and strategy to communicate the importance of diversity in relation to state education and workforce needs and demographic trends.
- With data, trends, known resources and strategic communication plans in hand, the S&T Council should, in collaboration with the state EPSCoR Committee, convene an annual meeting of broadening-participation stakeholders for the express purpose of developing collaborative funding proposals to develop and/or support state-relevant, broadening-participation programs and resources. At each annual meeting both a short-term strategy and a long-term strategy should be developed. Proposal development staff from Oklahoma institutions should be asked to participate and facilitate the development of these proposals.

4.2 Innovation Recommendations

RECOMMENDATION 6: PRIORITIZE

The state should prioritize rebuilding investment into science, technology and innovation when funds are available.

OCAST is the state's primary funding mechanism for supporting science, technology and innovation. However, OCAST's appropriations over the past 10 years (**Figure 2**) reflect an annualized budget cut of -3.8% from the high of \$22.9M in FY08 to its current \$15.9M in FY16, for a total of 30% over a 8-year period with additional cuts inevitable. We recommend a measured approach to restoring OCAST funding as the budget becomes available to do so.

RECOMMENDATION 7: REPORT

Ensure that Oklahoma's citizens receive the maximum benefit from state investments in science and technology.

The state should publish an annual "Governor's S&T Innovation Report" to give the administration's perspective on the issues related to the state's science and technology economy, describe the achievements of the past year, the rankings and S&T Indicators for that year, and reflect upon the plans for the coming year. The plan should be prepared by the S&T Council, in close collaboration with OCAST and the state EPSCoR Committee. Included in this report will be the strategic focus and long-term objectives that will be achieved through the state's investment.

RECOMMENDATION 8: DISCUSS

The Governor should convene a focused summit on the "Future of the Oklahoma's Science & Technology Enterprise", organized by OCAST/ OSTRAD, and including all primary stakeholders and decision-makers, to discuss the role of S&T innovation and investment in the state's economy and receive recommendations from stakeholders regarding future directions.

It is essential in a modern, educated society that citizens understand the benefits and costs of S&T advances and innovations. The S&T Council recommend that the administration engage the state Legislature, and other key state leaders and stakeholders to discuss issues pertaining to the growth of a science and technology economy within the state. Cooperation among multiple entities is

important to realize the wider impact of science, engineering, and technology in Oklahoma society and its impact on the state's industrial base. Entities involved should include: education, business and commerce organizations, national and domestic security entities, education and workforce development organizations, and entities focused on health and safety, energy and environment, culture and the arts, entertainment, and other societal interests and needs.

4.3 Research and Development Recommendations

RECOMMENDATION 9: COORDINATE II

Coordinate with the state EPSCoR Committee as a mechanism for helping execute the State S&T Plan.

Oklahoma requires a coordinated strategy for Science and Technology development. Unification of strategic plans across sectors and agencies is required. Thus the S&T Council recommends:

- Establishing sub-committees within the Governor's S&T Council and the state EPSCoR Committee to ensure effective communication and a strong working relationship between the two. Oklahoma has a new EPSCoR State Strategic Plan which, coupled with the updated S&T Council's Strategic Plan, affords an unprecedented opportunity for collaboration and thereby advancing the state's S&T agenda.

RECOMMENDATION 10: COLLABORATE

By utilizing the collective capabilities of Oklahoma's academic, corporate, tribal, K-12, and non-profit research institutions, establish a single, virtual research organization in Oklahoma – informally termed here “OneOklahoma” – that can be brought to bear on certain national and international challenges and opportunities.

Statewide coordination would benefit from a single organization under which strong linkages can be established. In alignment with this goal the S&T Council further recommends:

- Coordination of faculty recruiting across academic institutions to maximize synergy, leverage resources, and build stronger linkages to promote collaboration and the development of critical mass that cannot be achieved within a single institution. Additionally, lists of potential faculty and staff hires 2-4 years into the future should be developed to facilitate the identification of clusters within and across institutions and disciplines, and to promote the sharing of resources, thereby generating new areas of critical mass that resonate with state and national goals.
- Creation of special faculty positions, such as adjunct or visiting faculty status and creative appointments within companies, tribal organizations, and non-profit research organizations, to help faculty understand that they are both part of a single institution but also of a state in which institutions collaborate in novel and powerful ways.

- Collaborative development of materials to promote the state and its education and research resources, including cross-institutional capabilities, to assist in promoting a positive message for recruiting. Included within these materials should be information and messages about the importance of broadening participation and access to education for all populations.
- Formally establishing the “OneOklahoma” concept via a simple memorandum of agreement among its participating institutions. A governance model consisting of a board or committee comprising the research and technology officers, and other leaders of each participating organization would provide effective leadership, especially the agility so vital to both marketing the “OneOklahoma” concept and actively pursuing funding opportunities. These leaders could meet regularly, but at least once per year, to facilitate the strategic faculty recruiting noted above.
- The S&T Council and the state EPSCoR Committee should engage Oklahoma's research and education institutions, and private companies, to develop a portfolio analysis of key areas of research strengths and prospective areas for economic growth. This analysis should be performed yearly, emphasizing points of research capability intersection of organizations within Oklahoma as well as with federal agencies. To be effective, this information must be disseminated and explained to university faculty and other researchers to allow them to plan strategically. Additionally, and in collaboration with the state EPSCoR Committee and/or OCAST, a statewide Researcher Network should be established to emphasize the

importance of research to Oklahoma. The Network should bring together researchers and investigators who have benefitted from OCAST, and EPSCoR and NSF IDeA investments, and enhance the ability of Network participants to engage in activities ranging from promotion of research to the pursuit of collaborative funding, to representing EPSCoR, NSF, IDeA and/or Oklahoma in state and federal hearings.

The S&T Council further recommends:

- Development of internships and research exchanges for excellent students and faculty from institutions that serve underrepresented populations.
- Creation of an industry-focused Applied Research and Development Center that encompasses capabilities from public and private research and educational organizations and focuses on addressing applied R&D problems relevant to state strategic interests and directions. The problems addressed by the Center would be of a size and scope that exceed the capabilities of any given institution working on its own. The administrative structure of the Center should be minimally bureaucratic to facilitate creativity and flexibility. Key to the Center's mission would be the development of STEM talent via creative utilization of students at all stages of learning, as well as post-doctoral fellows, professional researchers public and private, and faculty whose principal appointments are in another institution but who benefit from affiliating with the Center. The work products of the Center should provide pathways of technology and knowledge to

government and private industry and should serve as a means for creating, retaining and attracting high-technology companies to Oklahoma.

- Active promotion of the state's innovative research, technology, corporate, and education enterprises, but within the context of a less hectic pace of life, a strong work ethic, and a more effective collaborative ethos, than is found on the coasts or in major cities. The state needs to more effectively take advantage of the Midwestern culture present in Oklahoma, which is attractive but which typically is not fully appreciated until people actually visit our state and campuses.

RECOMMENDATION 11: AIM HIGH

Undertake a concerted effort to establish a major federal research laboratory in Oklahoma and/or provide space for national observing and research support facilities.

Oklahoma is fortunate to host a number of military bases and the Mike Monroney Aeronautical Center. Although none of these valuable and substantial institutions focuses principally on research, they provide powerful organizing themes and supporting capabilities for either a major laboratory or observational facilities, particularly as new opportunities emerge in areas such as unmanned aerial systems. Oklahoma does in fact host one modest sized NOAA research laboratory and two NOAA operations centers, plus a new Department of Interior climate research center. These too provide a base upon which to build in weather and climate research, which is a strategic priority for both research and economic development, and which has

important linkages to other priority areas, such as aerospace/unmanned aerial systems, agriculture, energy and water. Therefore:

- Building on the Recommendations listed above, we additionally recommend that the Governor engage the state legislature, congressional delegation, and other key state leaders and stakeholders to develop a long-term strategy for establishing a major federal research laboratory or center, and/or a major national observing and research support facility, in Oklahoma. Although this substantial effort cannot be done quickly, the benefits for the long term cannot be overstated. The Governor should determine the best approach for organizing and planning.

RECOMMENDATION 12: ADVOCATE

Explore the creation of an industry-led advocacy group to bring important corporate and other interests to the table when planning, defining and executing the state's economic development/research and development agenda.

Both basic research and applied research are essential to the long-term health of a state's science and technology economy. The balance between them is a complex issue involving many viewpoints from the state's commercial and educational sectors. An advocacy group could sponsor a statewide conference on key research and development topics (viz. Recommendation 8), with two or three sessions/topics involving academia, industry, non-profits and state agencies. In addition, the group would serve as a mechanism to identify and organize R&D capabilities of direct interest to its participants, thereby yielding direct and tangible benefits to industry.

This entity could also serve as an additional mechanism by which to advocate for science and technology at the state and federal levels, and bring additional visibility to the importance of science and technology in state economic and educational vitality.

RECOMMENDATION 13: PROMOTE

Develop and execute a coordinated strategy for promoting/marketing Oklahoma science and technology nationally.

It is vitally important that achievements in research and development, and their related impacts on education and economic development, be promoted at the national level. Although local press is valuable, the targeting of major news outlets such as the New York Times and Wall Street Journal is critical and requires both connections as well as exceptional content. Likewise, promoting Oklahoma's science and technology strengths – as has been done with notable success in areas such as weather, unmanned systems and energy – is critical for crafting a recognized state identity that will be attractive to future students, leaders, and private companies. Multiple audiences exist, ranging from Congress to federal agencies to the general public, and thus a multi-faceted approach will be needed. In some cases, the communication will be performed by the institutions themselves to penetrate specific markets and target specific audiences. However, success will be predicated upon effective coordination from the state down to the institutional level. Therefore, the S&T Council recommend:

- The office of the Chancellor, and the Oklahoma Department of Commerce, OCAST and the Secretary of Science

and Technology, develop and execute a coordinated strategy for promoting/marketing Oklahoma science and technology nationally. Involvement of universities, private companies, and non-academic research organizations and foundations is likely to be a key component, and in addition to targeting standard press outlets, an emphasis should be placed on social media frameworks.

- In support of the above, the Chancellor for Higher Education, and Secretary of Science and Technology should take the lead in highlighting, in their speeches and presentations, that research is a vital component of the state's future. Such messaging has never been easy but has never been more important than at present. A wealth of supporting information is now available, especially from recent reports by the National Academy of Sciences and the American Academy of Arts and Sciences.

This coordinated strategy also could serve as a means for promoting hands-on, authentic research experiences to students at all levels of education as well as to teachers, parents, and the public. These experiences would be designed to emphasize that learning can take place in structured ways outside the classroom, including via online resources.

ONEOklahoma: A Strategic Plan for Science & Technology 2016

Appendix: Notes on Recommendations from the 2012 Strategic Plan

Below we list the recommendations from the 2012 Strategic Plan, along with notes on progress.

1. **Improve STEM teacher's skills and teaching methods.**

- a. Recruit more highly qualified STEM teachers in common education and provide incentives, resources and assistance to those already teaching STEM subjects.

Progress: *The situation has become more difficult since 2012. There is a major shortage of teachers in Oklahoma of all types, 50% of which are in STEM.*

- b. Modernize STEM teaching methods at colleges and universities to reduce the attrition from STEM degree programs.

Progress: *There is a continuing effort to achieve this.*

2. **Improve student performance in STEM subjects.**

- a. Establish "STEM-ready" designation to identify those students who achieve a minimum score on ACT examinations.

Progress: *Oklahoma average ACT scores in Math and Science remain the same as in previous years. ACT scores remain the best indicators of STEM readiness for college.*

- b. Create a statewide "distance learning" capability (e.g. using the "First Chance" program as a possible model).

Progress: *Some admirable progress but only in certain regions of the state.*

3. **Integrate STEM programs across the state.**

- a. Create a coordinator of STEM programs within the state superintendent's office.

Progress: *Done. The STEM Coordinator position has now evolved into an excellent staffed STEM team.*

4. Promote STEM education in Oklahoma.

- a. Establish a system of “STEM Communities”

Progress: Excellent progress. A formal system of STEM Communities has been established under state legislation known as “A STEM State of Mind”. Additionally, the Governor’s “Oklahoma Works” initiative is based on regional key economic networks (KENs) to improve education and training by region.

- b. The Governor should initiate and lead a statewide marketing campaign to promote a “STEM State of Mind”

Progress: Continuing. Several STEM Communities awarded and recognized.

5. Utilizing the collective capabilities of Oklahoma’s academic research institutions, establish a single virtual research organization in Oklahoma – termed here OneOklahoma – that can be brought to bear on certain national and international challenges and opportunities.

Progress: There has been significant discussion, organization and movement toward achieving this target, along with some successes for federal funding in certain research areas (e.g. high-performance computing, UAS). Although no such organization has yet been formally established, discussion between the S&T Council and the state’s EPSCoR Committee has moved the state closer to this recommended goal.

6. Create a shared governance and utilization model for selected research facilities and field stations in Oklahoma.

Progress: Little specific progress, but under discussion in connection with Recommendation 5.

7. Undertake a concerted effort to establish a major federal research laboratory in Oklahoma and/or provide space for national observation and research support facilities.

Progress: Continuing. Some opportunities identified (e.g. in relation to UAS research) but no specific success to date.

8. Facilitate mechanisms whereby credentialed researchers from Oklahoma’s institutions, including nonprofits, can provide consultative support to state legislators in their development of laws and policies that impact research and technology development.

Progress: No real progress. This happens on an ad hoc, group-by-group, issue-by-issue basis, but there is no systematic consultative procedure in place. The state EPSCoR committee could perform as a consultative body.

9. Continue providing required cash match to certain federal grant programs.

Progress: Continuing, even in difficult budget years.

10. The Oklahoma Department of Commerce should maintain an inventory of the state's science and technology companies.

Progress: This is done through ODOC's excellent research department.

11. State associations and alliances involved in the science and technology industry should sponsor a statewide conference to showcase existing science and technology companies, as well as academic institutions, Native American nations and others involved in science and technology.

Progress: This is done through OCAST's annual Technology Showcase.

12. OCAST, i2E or another appropriate organization should lead a focused initiative to target and recruit dormant, private capital for use in Oklahoma's science and technology companies.

Progress: i2E, funded in part through OCAST, has led an aggressive initiative to raise private capital through the Seed-Step Angel program. To date more than 80 high net-worth individuals across the state are investing.

13. The Oklahoma Department of Commerce should establish a one-stop-shop for companies seeking assistance, directing the companies to OCAST, the Procurement Technical Assistance Center, i2E, CareerTech, or other organizations, as appropriate.

Progress: The ODOC essentially does each of these functions.

14. The state legislature should consider legislation to promote investment by S&T companies in their Oklahoma facilities.

Progress: No action. Companies make these decisions independently.

15. The public and private sector should promote the export of science and technology goods and services.

Progress: The ODOC, regional Chambers of Commerce, and OCAST and its strategic partners i2E and the Oklahoma Manufacturing Alliance (OMA) work closely with Oklahoma companies to assist in exports (e.g. partnerships at international trade shows, etc.).



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